STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME II

STANDARD OPERATING PROCEDURE

FOR

AIR QUALITY MONITORING

APPENDIX Z

RUPPRECHT & PATASHNICK SERIES 1400a TEOM PM10 MONITOR

MONITORING AND LABORATORY DIVISION

JANUARY 1995

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STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME II

STANDARD OPERATING PROCEDURE

FOR

AIR QUALITY MONITORING

APPENDIX Z.l.0

STATION OPERATOR'S PROCEDURES

FOR THE

RUPPRECHT & PATASHNICK SERIES 1400a TEOM PM10 MONITOR

MONITORING AND LABORATORY DIVISION

JANUARY 1995

Z.1.0 GENERAL INFORMATION

Z.1.0.1 PURPOSE

These procedures are intended to supplement the Rupprecht & Patashnick (R&P) Model 1400a Tapered Element Oscillating Microbalance (TEOM) Operating Manual (R&P Manual). They will direct the user to appropriate sections of the R&P Manual and describe modifications in hardware or procedures which may have been implemented by the Monitoring and Laboratory Division (MLD). It is recommended that the R&P Manual be utilized in conjunction with these written procedures during installation, operation, or calibration.

Z.1.0.2 GENERAL DESCRIPTION

In October 1990, the United States Environmental Protection Agency (U.S. EPA) designated the R&P TEOM as an equivalent method for the determination of 24-hour average PM10 concentrations.

The TEOM continuously monitors PM10 levels by capturing particulate on a sample filter attached to a vibrating inertial mass transducer. Using the rate of mass accumulation on the filter and the flowrate through the sample (main) flow controller, the TEOM's microprocessor calculates the mass concentration. The flowrate through the sample filter is set at a nominal 3.0 liters per minute (LPM). A bypass (auxiliary) flow is used to provide an additional 13.67 LPM for a total flowrate of 16.67 LPM, the design flow of the size selective inlet. A schematic diagram of the TEOM's flow system is shown in Figure Z.1.0.2. Additional information on its operation is contained in Section 1 of the R&P Manual.

There are currently two models of TEOM in use by the Air Resources Board (ARB). The Series 1400a and an earlier model, the Series 1400. The earlier model units have been retrofitted by R&P to include Model 1400a software and keypad. This upgrade eliminates the need for a separate personal computer to edit the TEOM's software configurations. The only significant difference remaining between these two models is their analog output voltage scale. The 1400a has selectable output voltages of 0 to 1, 2, 5, and 10 volts direct current (vdc). The 1400 (with or without upgrade) analog output is fixed at 0 to 10 vdc. When the 1400 is interfaced with a Bristol chart recorder having a 0 to 1 vdc input range, a calibrated intermediate resistive voltage divider must be used. Additional details of their differences can be found on Page 1 (one) of the R&P Manual.

Z.1.0.3 SAFETY

Installation, operation or calibration of these instruments should only be attempted by properly trained personnel. High voltages may be present in the TEOM sensor and control unit enclosures.

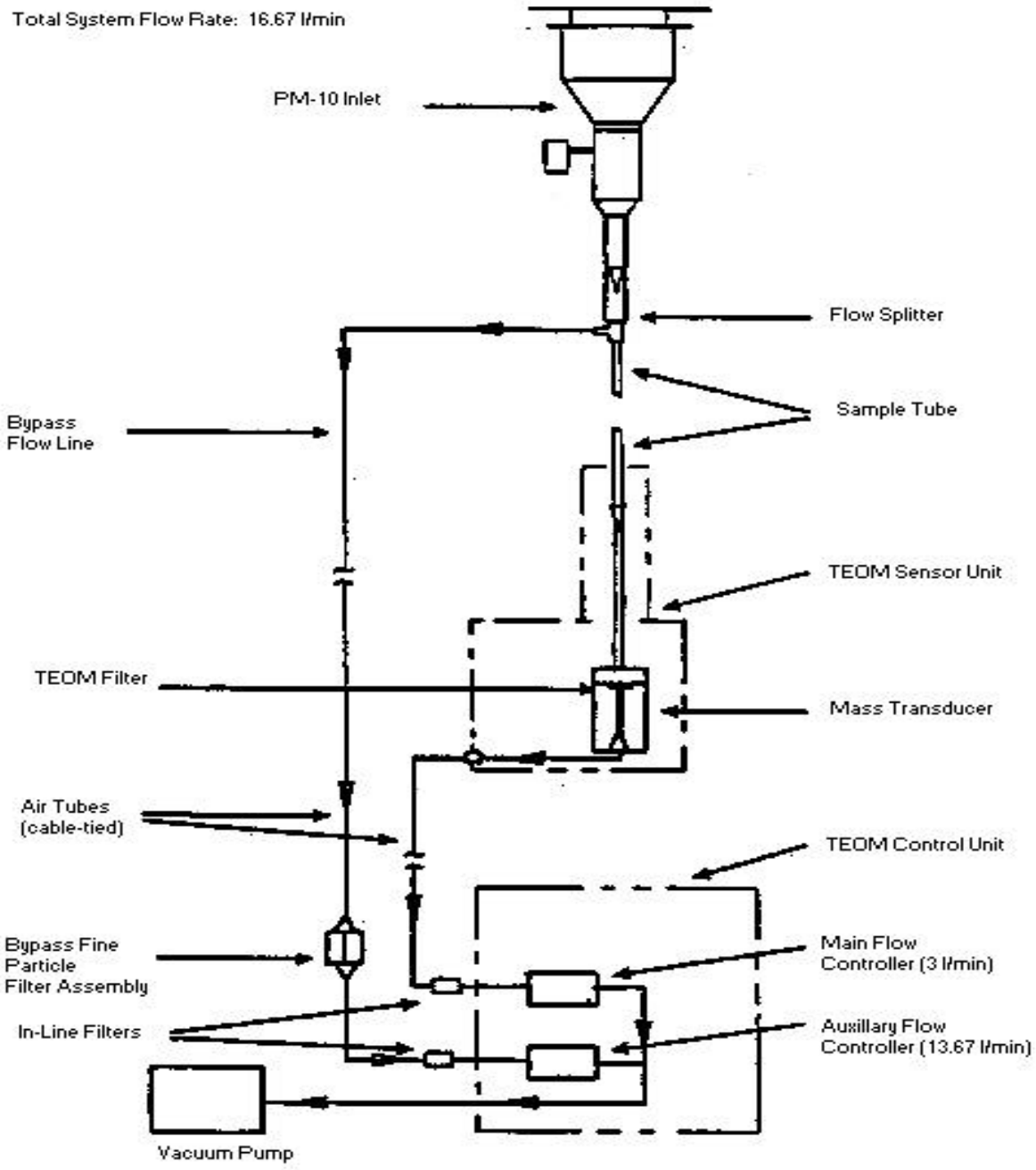


Figure Z.1.0.2
Diagram of Flow System

Z.1.1 INSTALLATION PROCEDURE

Z.1.1.1 COMPONENTS

The TEOM consists of two main components, the electronics control and sensor units. Additional components supplied by R&P are listed on Page 2-3 of the R&P Manual. Typical ARB installations should also include the following items in addition to those listed in the R&P Manual:

1. An additional PM10 inlet (R&P or Sierra-Andersen Model 246b).

2. A sufficient length of internally polished, to 15 micro-inch roughness, 1/2 inch OD stainless steel (ss) tubing (Valex Corporation Type 3-16LS, MO #159137-01 or equivalent) for a one-piece sample probe.

3. A heavy-duty, photographic type tripod for support of inlet.

4. A sufficient length of 3/8" OD x 1/4" ID flexible tubing for remote vacuum pump installations. Larger ID heavy-wall tubing is recommended for runs longer than 50 feet.

5. Additional sample, inline and auxiliary flow filters.

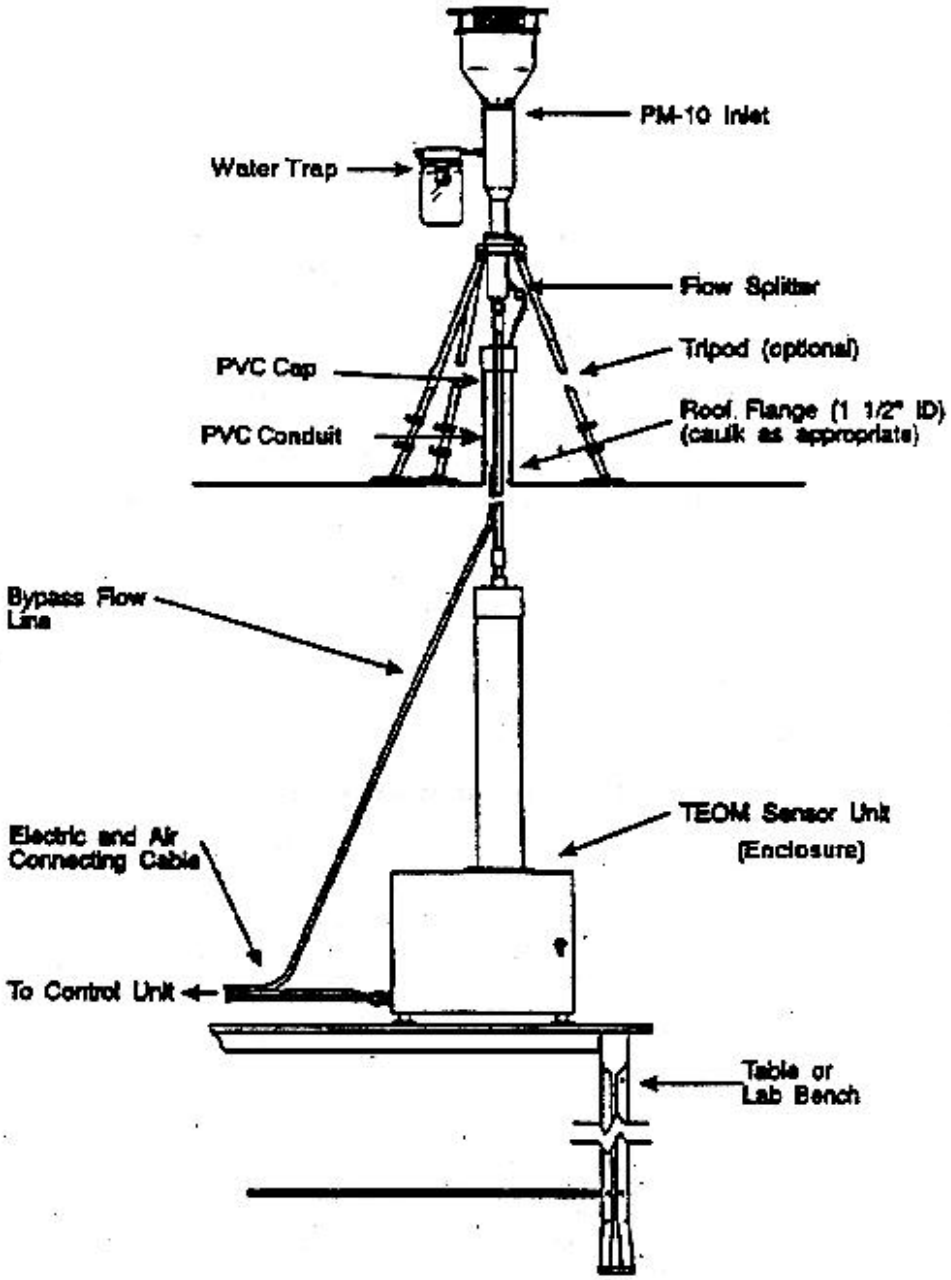
6. Monthly Quality Control Maintenance Check sheet (Figure Z.1.2.1).

Z.1.1.2 INSTALLATION

The System Installation directions in Section 2 of the R&P Manual should be followed as closely as possible. Two factors of primary concern that will determine the placement of the sensor unit are the need for a sturdy, vibration free mounting and a straight vertical access to the roof for the sample probe.

Installations for mounting of the sensor (see Figure Z.1.1.2) may include counter-tops, reinforced wall shelves or vibration isolated instrument rack shelves. The sample probe and auxiliary flow lines should be run in a 2 to 3 inch ID heavy-wall, sunlight resistant PVC conduit which starts flush with the interior ceiling and ends 30 inches above roof level. Seal the roof/conduit juncture with a roof jack equipped with a vinyl collar. Install a PVC cap on the outside end of the conduit to prevent rain entry. The cap will need to be drilled with one 1/2 inch hole on center for the probe and one 3/8ths inch hole off center for the auxiliary flow line. This should provide a sturdy, rain tight mounting for the tripod, flow splitter and inlet.

Insulate the sample probe between the sensor housing and the exterior roof with foam pipe insulation. This will minimize temperature fluctuations caused by air conditioning drafts.



Z.1.1.2
Diagram of Typical Installation

Z.1.1.3 SOFTWARE CONFIGURATION

The software configuration consists of setting various parameters in the TEOM's software such as choice of analog outputs, temperatures, pressures, and flow rates. These procedures are detailed in Sections 4 and 5 of the R&P Manual.

Typical ARB installations have settings which may differ from examples shown in the R&P Manual. The following settings are currently being used at various ARB monitoring sites:

NOTE: If the TEOM is shut off, an internal battery will hold the configured settings.

SET ANALOG OUTPUTS (Menu Screen 04); see page 5-3 of R&P Manual

Max Volt	1-VDC	- Sets Output Range Voltage to 0-1.0 VDC
A01 Var	Mass Conc	- Selects Mass Conc. as output of A01
AO1 Min	-50.00	- Selects -50 as Minimum Mass Concentration
AO1 Max	950.00	- Selects 950 as Maximum Mass Concentration
Jumpers	2-VDC	- Reflects Internal Jumper Connections

These settings correspond to an output slope of 1000 and an intercept of -50. The purpose of this offset is to minimize negative voltage outputs if the TEOM's mass concentration readings fall below zero. This offset must be considered when connecting the TEOM to an external recording device such as a chart recorder or data logger.

SET TEMPS/FLOWS (Menu Screen 12); see page 4-19 of R&P Manual

The settings shown on Screen 12 of the R&P Manual are correct for most applications. However, in 1993-1994, the U.S. EPA granted conditional approval for modifications to the main flowrate and temperature settings under provisions contained in Section 2.8 of Appendix C to 40 CFR part 58.

The flowrate modification consists of operating the TEOM at the reduced main (sample) flowrate of either 1.0 or 2.0 LPM if it is equipped with the proper flow splitter (available from R&P). The reduced flowrate provides an extended interval between sample filter changes in areas of high particulate concentrations. Operating at a

reduced flowrate may also reduce loss of mass on the sample filter by decreasing ventilation through same.

The temperature modification consists of operating the TEOM at the reduced temperatures of:CaseT 30, AirT 30, CapT 0 (off), and EnclT 25 degrees Centigrade (C). This modification is intended to reduce volatilization of the sample and thus provide better correlation of the data with conventional gravimetric PM10 measurement methods. This temperature configuration is only permitted if certain conditions exist and with approval by the U.S. EPA on a case by case basis. For more information, see R&P's Technical Note #4, dated October 1993.

T-A/S 25.00 25.00

These are the average ambient (outdoor) and-reference standard temperature settings, left to right respectively.

The average temperature setting should be set to the 24-hour average outdoor temperature expected at the TEOM site. This setting should be adjusted seasonally, i.e., winter, spring, summer and fall, in order to minimize temperature caused errors in the flowrate calculations performed by the TEOM.

The standard temperature setting should be set at 25 degrees C. This is the U.S. EPA standard temperature to which the flowrates and hence, the mass concentration calculations are referenced.

P-A/S 1.000 1.000

These are the average and standard barometric pressure settings, left to right respectively.

The average pressure setting should be set to the barometric pressure in atmospheres (atm) of the site's elevation. If the elevation or pressure in millimeters of mercury (mmHg) is known, the corresponding pressure in atm is the same value as the altitude correction factor (ACF) shown in Table Z.1.1.3. The pressure in atm may also be calculated by the following formula:

$$Pa(atm) = \frac{Pa(mmHg)}{760(mmHg)}$$

Where: Pa(atm) = ambient pressure in atmospheres
Pa(mmHg) = ambient pressure in millimeters of mercury
760(mmHg) = standard pressure in mm Hg

The standard pressure setting should be set to 1.000 atm. This is the U.S. EPA standard pressure to which the flowrates are referenced.

Fadj Main 1.000 and FAdj Aux 1.000

These factors are used by the TEOM's software to adjust for deviations of the main and auxiliary flowrate setpoints from the actual flowrates. They are determined by a proportional comparison to the actual or true flowrates as measured with a transfer standard during the software calibration. Additional information on these factors is contained in Section 8.2 of the R&P Manual.

NOTE: These flowrate adjustment factors change the actual flowrates but this change will not be reflected by the TEOM's flowrate display. The TEOM's displayed flowrate is an indicated flowrate only. It is neither affected by the FAdj settings nor is used by the TEOM to calculate the actual or true flow in SLPM. The conversion to SLPM is based on the flowrate setpoints.

Z.1.1.4 ESC MODEL 8800 DATA LOGGER CONNECTION

The TEOM's analog output (A01-mass concentration), as previously selected in the Software Configuration (Z.1.1.3), should be connected to the selected analog input channel of the ESC data logger. Using the supplied 15-Pin D-Connector and signal cable, connect the front or rear (preferred) Analog I/O of the TEOM's Control Unit to the ESC's analog input. A schematic diagram of the TEOM's analog output wiring assignments is shown in Figure Z.1.1.4.

Z.1.1.5 ESC DATA LOGGER AND AQDAS CONFIGURATION

Configure the selected ESC and AQDAS TEOM channel as shown in Figure Z.l.l.5. Notice that the slope of 1000 and the intercept of -50.00 are due to the settings previously selected in Software Configuration Section Z.1.1.3. These settings correspond to a full scale (1.0 volt) value of 950 micrograms per cubic meter ($\mu g/m^3$).

NOTE: If the earlier TEOM model 1400 is used without a voltage divider, the input range of the data logger must be set to 10 volts.

Altitude	ACF	Pressure mm Hg
100	0.997293	757.9428
200	0.9936	755.1361
300	0.989921	752.3397
400	0.986255	749.5537
500	0.982603	746.778
600	0.978964	744.0126
700	0.975339	741.2574
800	0.971727	738.5124
900	0.968128	735.7778
1000	0.964543	733.053
1100	0.960972	730.3384
1200	0.957413	727.6338
1300	0.953868	724.9393
1400	0.950335	722.2548
1500	0.946816	719.5802
1600	0.94331	716.9155
1700	0.939817	714.2607
1800	0.936336	711.6157
1900	0.932869	708.9805
2000	0.929415	706.355
2100	0.925973	703.7393
2200	0.922544	701.1333
2300	0.919127	698.5369
2400	0.915724	695.9501
2500	0.912333	693.3729
2600	0.908954	690.8053
2700	0.905588	688.2471
2800	0.902235	685.6985
2900	0.898894	683.1593
3000	0.895565	680.6294
3100	0.892249	678.109
3200	0.888945	675.5979
3300	0.885653	673.096
3400	0.882373	670.6035
3500	0.879105	668.1201
3600	0.87585	665.646
3700	0.872607	663.181
3800	0.869375	660.7252
3900	0.866156	658.2785
4000	0.862948	655.8408
4100	0.859753	653.4121
4200	0.856569	650.9924
4300	0.853397	648.5817
4400	0.850237	646.18
4500	0.847088	643.7871
4600	0.843951	641.4031
4700	0.840826	639.0279
4800	0.837712	636.6615
4900	0.83461	634.3038
5000	0.83152	631.9549
5100	0.82844	629.6147
5200	0.825373	627.2832
5300	0.822316	624.9603
5400	0.819271	622.646
5500	0.816237	620.3402
5600	0.813215	618.043
5700	0.810203	615.7543
5800	0.807203	613.4741
5900	0.804214	611.2023
6000	0.801236	608.939
6100	0.798268	606.684
6200	0.795312	604.4374
6300	0.792367	602.1991
6400	0.789433	599.9691
6500	0.78651	597.7473
6600	0.783597	595.5338
6700	0.780695	593.3284
6800	0.777804	591.1313
6900	0.774924	588.9422
7000	0.772054	586.7613
7100	0.769195	584.5885
7200	0.766347	582.4237
7300	0.763509	580.2669
7400	0.760682	578.1181
7500	0.757865	575.9772
7600	0.755058	573.8443
7700	0.752262	571.7193
7800	0.749477	569.6021
7900	0.746701	567.4928
8000	0.743936	565.3913
8100	0.741181	563.2976
8200	0.738436	561.2117
8300	0.735702	559.1334
8400	0.732977	557.0629
8500	0.730263	555
8600	0.727559	552.9448
8700	0.724865	550.8972
8800	0.72218	548.8571
8900	0.719506	546.8246
9000	0.716842	544.7997
9100	0.714187	542.7822
9200	0.711542	540.7722
9300	0.708907	538.7697
9400	0.706282	536.7745
9500	0.703667	534.7868
9600	0.701061	532.8064
9700	0.698465	530.8334
9800	0.695878	528.8676
9900	0.693302	526.9092
10000	0.690734	524.958
10100	0.688176	523.014
10200	0.685628	521.0772

ACF = 1.001*e^(-.0000371*altitude in ft)

Table Z.1.1.3
Altitude Correction Factors

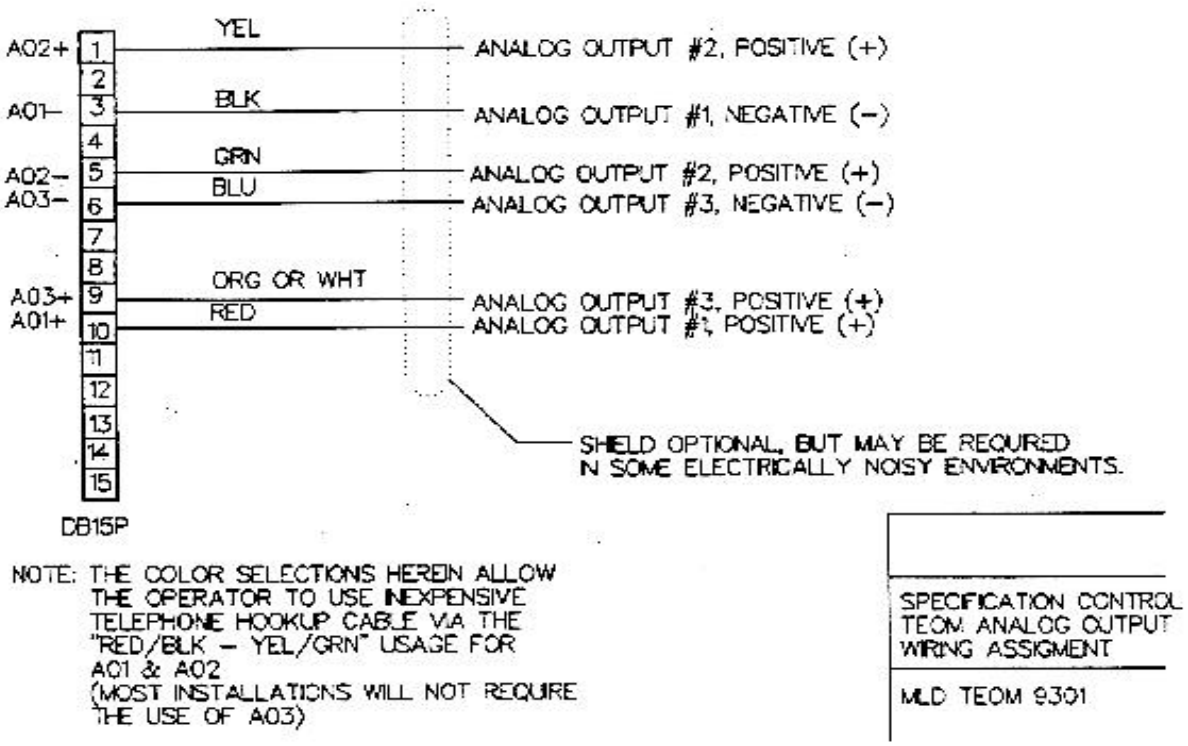


Figure Z.1.1.4
Analog Output Wiring Assignments

```
DDDDDDDDDDDDDDDDDDDDDDDDD [SITE DATA LOGGER CONSOLE MODE]

CHANNEL NUMBER: 09
CHANNEL NAME: TEOM
CHANNEL TYPE: 9
STORE HOURLY AVERAGES: Y
      HOURLY SIGMAS: N
      HOURLY % VALID: N
      HOURLY RANGE: N
STORE AUX AVERAGES: N
CHANNEL UNITS: UG/M3
VOLTS FULL SCALE:  1.000
SLOPE:  1000.
INTERCEPT: -50.00
DECIMAL POSITIONER: 1
MAX READING:  950.0
MIN READING: -50.00
MAX RATE OF CHANGE:  1000.
ALARM INTERVAL [N,M,A,H]: N
BAD STATUS= XXXXXXXX XXXXXXXX
CALIBRATION TYPE: N
10-STEP CALIBRATION: N
ON-LINE: Y
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
                  F1 - MAIN  F2 - RETURN
```

```
IMREC:  157 PAGE:  1 OF 2[CHANNEL CONFIGURATION EDITOR] MMMMMMMMMMMMMMMMMMMMMMMM:
:   SITE CODE: 3900252       DATA LOGGER ID: 28       CHAN NUM: 09          :
:                            < CHANNEL DATA >                                :
:   PARM CODE: 8110279 PARM NAME: TEOM        AGENCY:     A    PROJECT: 11   :
:   UNIT CODE: 01 UNIT NAME: UG/M3 CHAN TYPE: 9 AUX CHAN1:    AUX CHAN2:     :
:                            < STORE FLAGS FOR HOURLY DATA>                  :
:   AVERAGE:    Y          SIGMA:     N       % OF VALID: N    RANGE:     N  :
:                            < STORE FLAGS FOR AUXILIARY DATA>               :
:   AVERAGE:    N          SIGMA:     N       % OF VALID: N    RANGE:     N  :
:                               < MISCELLANEOUS >                            :
:   RMS FLAG:   Y          AVG ENABLE: Y      COH FLAG:    N   SAMP INT:  1  :
:   SLOPE:       1000.     INTERCEPT: -50.00  DECIMAL:     1   AVG PERIOD: 1 :
:   MAXIMUM:     950.0     MINIMUM:   -50.00  MAX ROC:  1000.  PROBE HI:   6 :
:   FULL SCALE:  950     FULL VOLTS:   1.000  BAD STATUS: XXXXXXXXXXXXXXXX   :
:                               < ALARM CONTROL DATA >                       :
:   ALARM LINE:            ALARM TYPE:    (N,M,A,H)                          :
:   HIGH LIMIT:            LOW LIMIT:_ _.            ROC LIMIT:              :
:                                                                            :
:    F1-MAIN  F2-RETRN F3-SAVE          F5-NSCRN         F7-PRINT            :
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMC CENTRAL WKST'N   - 17MMM<
```

Figure Z.1.1.5
ESC Data Logger and AQDAS Configurations

Z.1.2 QUALITY CONTROL MAINTENANCE CHECKS

Z.1.2.1 GENERAL INFORMATION

Detailed directions of routine maintenance procedures are described in Section 7 of the R&P Manual. Based upon these manufacturer's procedures and U.S. EPA requirements, the monthly quality control checksheet shown in Figure Z.1.2.1 has been developed to alert the operator that maintenance is due and to provide a record of quality control actions.

Z.1.2.2 DAILY CHECK

On a daily basis, the TEOM's operation should be checked by viewing the Status Light, Percent of Filter display and chart recorder trace.

The red Status Light will turn on if a monitored parameter such as temperatures, pressures, or flowrates are out of operational bounds. See Page 4-4 of the R&P Manual for additional details.

The TEOM's sample filter must be changed before 90% is indicated on the display. Procedures for changing the filter are in Section 3 of the R&P Manual. Whenever the sample filter requires changing, the auxiliary flow inline filter should also be replaced unless it is of the extra capacity variety which may be replaced when necessary. A cleaned size selective inlet (as per Appendix F of the R&P Manual) should also be installed at this time. (See Operator Instruction #7 in Figure Z.1.2.1)

Z.1.2.3 WEEKLY CHECK

On a weekly basis, record the values found on the Main Screen of the TEOM's digital display onto the Monthly Quality Control (Q.C.) Maintenance Checksheet (Figure Z.1.2.1). A description of the Informational Lines is provided by the R&P Manual on Page 4-9.

Z.1.2.4 BIWEEKLY CHECK

Every two weeks, record the results of flow checks and the average pressure and temperature settings onto the monthly Q.C. checksheet.

The average pressure and temperature settings are factors used by the TEOM to calculate the mass concentration. They are accessed by scrolling down Menu Screen 12. These values should be the same as those in the most recent TEOM

Calibration Report (Figure Z.2.0.4) or the previous month's Quality Control Maintenance Checksheet (if no changes in the settings have recently been made).

The U.S. EPA requires that a precision flow check be performed at least every two weeks. This is accomplished by measuring the main and total (sum of main and auxiliary) flowrates and comparing these measurements to the TEOM's indicated flowrates as shown on its digital display. Record these readings and measurements on the check sheet and if they differ by more than +/-5%, take corrective action and notify your supervisor. The flows may be measured with a Vol-O-Flo, rotameter or mass flow meter (MFM).

NOTE: The TEOM flowrate display is in volumetric flow units (LPM). If the flow checks are measured with a MFM, standard liters per minute (SLPM) must be converted to LPM using the ambient pressure and temperature conditions present at the MFM. The equation for this conversion is as follows:

$$LPM = \frac{760\ mmHg}{Pa\ mmHg} \times \frac{Ta + 273\ °C}{298\ °C} \times SLPM$$

Where: Pa = Ambient Pressure in mmHg
Ta = Ambient Temperature in °C

The procedures to perform the precision flowcheck are as follows:

1. Disable or flag the TEOM channel of the data logger.

2. Record the TEOM's digital display readings of the main and total (sum of main and auxiliary) flowrates.

3. Remove the PM10 inlet and install R&P flow adapter.

4. Measure and record the total flowrate.

5. Remove auxiliary flow line and cap at flow splitter.

6. Measure and record main flowrate.

7. Re-install auxiliary flow line and PM10 inlet.

8. Re-enable or unflag data logger TEOM channel.

9. Calculate and record the percent deviation of TEOM's indicated main flowrate from the measured flowrate using the following formula:

$$\% \text{ Deviation} = \frac{\text{indicated LPM}}{\text{LPM}} \times 100$$

Where: Indicated = flowrate as indicated on TEOM's display
LPM = flowrate as measured by secondary device

Z.1.2.5 SEMIANNUAL CHECK

Every six months perform the following:

1. Clean the Air Inlet System as per Page 7-3 of the R&P Manual.

2. Replace the main and auxiliary flow inline filters.

3. Perform a flow controller software calibration and leak test.

NOTE: The leak test procedure to be followed is on Page 7-4 of the R&P Manual. In addition, perform the leak test after both the "as-is" and "final" portions of the semiannual software calibration.

Z.1.2.6 ANNUAL CHECK

Once per year perform the following:

1. Analog input and output calibration

2. Flow controller hardware calibration

Z.1.2.7 BIENNIAL CHECK

Every two years perform the following:

1. Mass transducer calibration verification

Z.1.2.8 PERFORM AS REQUIRED

1. Disassemble and clean size selective inlet concurrently with replacement of TEOM microbalance (sample) filter.

2. Replace auxiliary flow filter(s).

CALIFORNIA AIR RESOURCES BOARD
MONTHLY QUALITY CONTROL MAINTENANCE CHECKSHEET
TEOM

STATION NAME:_____ MONTH/YEAR:_____
STATION NUMBER:_____ TECHNICIAN:_____
PROPERTY NUMBER:_____ AGENCY:_____

WEEKLY CHECKS

FUNCTION	DIGITAL DISPLAY READINGS				
DATE CHECKED					
CURRENT STATUS CODE					
CURRENT OPERATING CODE					
% OF FILTER LIFETIME USED					
MASS CONCENTRATION					
DATA LOGGER READING					
CASE TEMPERATURE					
AIR TEMPERATURE					
CAP TEMPERATURE					
ENCLOSURE TEMPERATURE					
MAIN FLOW					
AUXILIARY FLOW					
NOISE					

BIWEEKLY PRECISION CHECKS

DATE	TOTAL FLOW			MAIN FLOW			AVERAGE PRESS/TEMP SETTING	
	INDICATED	LPM	% DIFF FROM 16.67	INDICATED	LPM	% DIFF FROM 3.00	PRESSURE	TEMPERATURE

OPERATOR INSTRUCTIONS:

1. Daily Check: Status Light, Percent of Filter (Record Weekly), Chart Trace.
2. Weekly Check: Record values of TEOM=s Digital Display.
3 Biweekly Check: Record results of Flow Check and Average Pressure and Temperature Settings. If Percent Difference of Flowrate is >5.0% from Expected Value, Notify you Supervisor.
4. Semiannual Check: As is and Final Flow Controller Software Calibration, Clean Air Inlet System, Replace Main Flow Inline Filter, Leak and Filter Test. Date Last Performed:_____
5. Annual Check: Analog In/Out and Mass Flowmeter Calibration. Date Last Performed:_____
6. Biennial Check: Mass Transducer Calibration Verification. Date Last Performed:_____
7. As Required: Clean PM10 Inlet Concurrently with Replacement of TEOM and Auxiliary Inline Flow Filters. Date Last Performed:_____

COMMENTS OR MAINTENANCE PERFORMED

DATE	

MLD-126 (1/96)

Reviewed By:_____
Date:_____

Figure Z.1.2.1
Monthly Quality Control Maintenance Checksheet

STATE OF CALIFORNIA

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VOLUME II

STANDARD OPERATING PROCEDURES

FOR

AIR QUALITY MONITORING

APPENDIX Z.2.0

CALIBRATION PROCEDURE

FOR THE

RUPPRECHT & PATASHNICK SERIES 1400a TEOM PM10 MONITOR

MONITORING AND LABORATORY DIVISION

JANUARY 1995

Z.2.0 CALIBRATION PROCEDURE

Z.2.0.1 GENERAL INFORMATION

Calibration of the TEOM consists of several procedures which are described step by step in Section 8 of the RLP Manual. The manufacturer's procedures should be followed, except as noted in these procedures, and documented on the TEOM Calibration Datasheet (Figure Z.2.0.3) and TEOM Calibration Report (Figure 2.0.4). The frequency of calibrations and the required apparatus are summarized as follows:

FREQUENCY	PROCEDURE	APPARATUS
1. Every 6 Months	Flow Controller Software Calibration	a. Flow rate transfer standard b. Calibrated thermometer and barometer c. R&P Flow Adapter d. 10 feet of 1/4" I.D. Tygon tubing e. R&P zero (particulate) filter f. Software Calibration Datasheet (Figure Z.2.0.3)
2. Every Year	Analog Calibration (input/output)	a. Calibration 3-1/2 digit multimeter b. 12" length jumper wire
	Flow Controller Hardware Calibration	a. Flow rate transfer standard b. Calibrated thermometer and barometer
3. Every 2 Years	Mass Transducer Calibration Verification	a. R&P Calibration Verification Kit or CARB certified preweighed sample filter

Z.2.0.2 FLOW CONTROLLER SOFTWARE CALIBRATION

This procedure consists of measuring the total, main, and auxiliary flowrates with a certified transfer standard and calculating the deviations from the inlet design and the TEOM's displayed and setpoint flowrates. These flowrate deviations are then corrected by editing the TEOM's FAdj (Flow Adjust) software settings for each flowrate, main and auxiliary, as previously mentioned in Z.1.1.3. In addition to the flow check, a leak test, a zero filter check, cleaning of the Air Inlet System per Page 7-4 of the R&P Manual, and replacement of filters, if necessary, should also be performed at this time.

In R&P's procedure for the flow check (Section 8.2 of the R&P Manual), the flow measurements are taken at the rear of the control unit after the main and auxiliary online filters have been removed. This raises concerns because the sampling train is disconnected from the system. It is recommended that the flows be measured at the flow splitter inlet as described on Page 8-14 (Flow Audit Procedure) of the R&P Manual. This method is consistent with flow measurement methods employed by MLD's Quality Assurance Section's audit procedures and Air Quality Surveillance Branch's Through-the-Probe calibration procedures.

The following is a summary of the software calibration procedure: Equations cited, (1), (2), etc., are from TEOM Software Calibration Datasheet (Figure Z.2.0.3).

1. Disable or Flag the TEOM channel of data logger.

2. Record on TEOM Software Calibration Datasheet (Figure Z.2.0.3) site and calibration standards information.

3. Using equation (1), calculate Temp/Press Correction Factor.

4. Record TEOM display readings onto the calibration datasheet, i.e., indicated flowrate displays and setpoints, average temperature, pressure and flow adjust settings.

5. Measure the total, main, and auxiliary flowrates (at the inlet) with a transfer standard per Page 8-1 of the R&P Manual.

6. Using equation (2) and (3), calculate and record the percent deviation of total flowrate from 16.67 LPM

   NOTE: If the "as-is" deviation is found to be greater than +/-10.0%, invalidate affected mass concentration data and initiate an Air Quality Data Action (AQDA) request, if necessary.

7. Using equation (4), calculate and record the percent deviation of the TEOM's main and auxiliary indicated (by display) flowrates from the transfer standard's flowrate (both in LPM).

   NOTE: These "as is" main and auxiliary flowrate deviations will be proportional to the corrective "final" FLOW ADJ settings in step12 below.

8. Using equation (5), the TEOM's main flowrate setpoint and the Avg Press and Temp settings, calculate and record the TEOM's main flowrate in SLPM.

   NOTE: The TEOM's mass concentration (in standard units) is calculated by the TEOM using the rate of mass accumulation and the main flowrate (in SLPM) which has been calculated by the TEOM using the main flowrate setpoint (in LPM) and the average pressure and temperature settings.

9. Using equation (6), calculate and record the percent deviation of the TEOM's calculated main flowrate from the transfer standard's flowrate (both in SLPM).

   NOTE: If the "as-is" deviation is found to be greater than +/-10%, correct the affected data by the amount of deviation and initiate an AQDA if necessary. Also, perform both hardware and analog calibrations before proceeding with the "final" portion of the software calibration.

9. Separate the sample probe from the sensor housing and install a zero (particulate) filter onto the sensor probe. The TEOM's mass concentration display should read less than +/-5.0 $\mu g/m^3$ in 30 minutes or less. Record the results of the zero filter check after the 30-minute waiting period.

11. Remove the zero filter, re-attach the sample probe and perform a leak check per Page 7-4 of the R&P Manual. Record resultant TEOM flowrate displays.

12. Adjust the TEOM's main and auxiliary FLOW ADJ settings to correct for the flow deviations calculated in step 7 and any other setting changes such as average temperature.

13. Repeat flow measurements for final software calibration, perform a zero filter check, leak test, and record results.

14. Perform a precision flow check of the main and auxiliary flowrates using the operator's flow measuring device. Record these results onto the Monthly Quality Control Maintenance Checksheet (Figure Z.1.2.1).

15. Assure that the TEOM is back in normal operation then ReEnable or Unflag data logger channel.

16. Prepare the TEOM Calibration Report (Figure Z.2.0.4) and submit along with datasheet (Figure Z.2.0.3); originals to station file and copies to the TEOM operator within 30 days.

Z.2.0.3 ANALOG CALIBRATION

This procedure consists of adjusting the analog input and output potentiometers on the TEOM's Analog Input/Output Board. Follow the directions written in Section 8.3 of the R&P Manual and record date of procedure onto TEOM Calibration Report (Figure Z.2.0.4).

Z.2.0.4 MASS FLOW CONTROLLER HARDWARE CONFIGURATION

R&P recommends that the analog calibration procedure be performed prior to the mass flowmeter hardware calibration. In addition, both of these calibrations should be performed on at least an annual basis or if the "as is" flow deviation is found to be greater than +/- 10% during the flow controller software calibration.

The hardware calibration procedure differs depending upon whether Tylan or Brooks flow controllers are installed. Refer to Section 8.4 of the R&P Manual for directions in performing the hardware calibration.

NOTE: The hardware calibration procedures set forth in the R&P Manual specify the use of a volumetric flow measuring device. This is because the flow indication shown on the TEOM's digital display is in LPM. If mass flowmeters (MFM) are used, it will be necessary to convert to LPM using the temperature and pressure conditions present at the MFM transfer standard. The equation for this conversion is in Section Z.1.2.4 of these procedures.

Record the date this procedure was last performed onto the TEOM Calibration Report (Figure Z.2.0.4).

CALIFORNIA AIR RESOURCES BOARD
TEOM SOFTWARE CALIBRATION DATASHEET

IDENTIFICATION

SITE NAME:	AGENCY:	ELEVATION:
SITE NUMBER:	AMBIENT TEMP (In Celsius):	AMBIENT PRESS (in mmHg):
DATE:	PROPERTY#:	TEMP/PRESS CORRECTION FACTOR (1)

CALIBRATION STANDARDS

STANDARD:	I.D. #:	CERTIFICATION DATE:
CERTIFIED RANGE		
SLOPE		
INTERCEPT		

TEOM READING	AS-IS			FINAL		
	BOTH	MAIN	AUX	BOTH	MAIN	AUX
FLOWRATE SETPOINT						
Oind(display) LPM						
AVG TEMP SETTING						
AVG PRESS SETTING						
FLOW ADJ SETTING						

TRANS STD READING	AS-IS			FINAL		
	TOTAL	MAIN	AUX	TOTAL	MAIN	AUX
MFM Display						
SLPM (Ostd)						
LPM (Oa) (2)						

RESULTS	AS-IS			FINAL		
	TOTAL	MAIN	AUX	TOTAL	MAIN	AUX
Dev from 16.67 (3)						
Dev from Tran Std (4)						
Ostd(calc) @ Set (5)						
Dev from Tran Std (6)						
Z Filter CK (ug/m^3)						
Leak Test (LPM)						

EQUATIONS:

(1) $\text{T/P Corr Factor} = \frac{760\text{mmHg}}{\text{Pa mmHg}} \times \frac{\text{Ta} + 273\ \text{C}}{298\ \text{C}}$

(2) Qa = T/P Corr Factor x Qstd

(3) $\%\text{Dev(tf)} = \frac{\text{Qa-16.67 LPM}}{\text{16.67 LPM}} \times 100$

(4) $\%\text{Dev(ts)} = \frac{\text{Main/Aux-Qa}}{\text{Qa}} \times 100$

(5) $\text{Qstd(calc)} = \text{Set pt} \times \frac{\text{Pavg}}{\text{1.00 atm}} \times \frac{298\ \text{C}}{\text{Tavg} + 273\ \text{C}}$

(6) $\%\text{Dev (calc)} = \frac{\text{Qstd(calc) - Qstd}}{\text{Qstd}} \times 100$

Where:

Pa	= Ambient Pressure (outdoor)
Ta	= Ambient Temp (outdoor)
Qa	= Volumetric Flow (LPM)
Qstd	= Standard Flow (SLPM)
SetPt	= Flowrate Setpoint
%Dev(tf)	= % Dev from 16.67 (total flow)
% Dev(ts)	= % Dev from Transfer Std
Main/Aux	= Main or Aux Display Flow
Qstd(calc)	= Calculated Main Flow (SLPM)
Pavg	= Average Press Setting
Tavg	= Average Temp Setting
%Dev(calc)	= % Dev from Transfer Std

Comments/Maintenance Performed: _____

MLD-127 (01/95) Calibrated by: _____ Checked by: _____

Figure Z.2.0.3
TEOM Software Calibration Datasheet

Z.2.0.5 MASS TRANSDUCER CALIBRATION

The results of the mass transducer calibration (verification) are used to indicate whether the calibration constant (Ko) of the mass transducer has significantly changed since the instrument left the factory. It is performed by using a certifiably weighed sample filter as supplied by R&P in the Calibration Verification Kit or an equivalent filter from MLD's Standards Laboratory. R&P recommends that if the indicated calibration constant differs by more than 2.5% from the original value, they should be contacted. It is recommended that this verification be performed every 2 years following the steps outlined in Section 8.5 of the R&P Manual.

Record the date this procedure was last performed onto the TEOM Calibration Report (Figure Z.2.0.4).

CALIFORNIA AIR RESOURCES BOARD
R&P TEOM PM10 MONITOR
CALIBRATION REPORT

TO: LOG NUMBER:
FROM: CALIBRATION DATE:
REPORT DATE:

IDENTIFICATION

Instrument: R&P TEOM	Site Name:
Model Number:	Site Number:
Property Number:	Site Location:
Serial Number:	
Previous Calibration Log Number:	Agency:
Elevation: Amb. Pressure:	Ambient Temperature: deqC

CALIBRATION STANDARDS

STANDARD	I.D. NUMBER	CERTIFICATION DATE	CERTIFIED VALUE OR FACTOR

CALIBRATION RESULTS

FUNCTION	AS IS	FINAL
% Deviation of Total Flow from 16.67 LPM		
% Deviation of Calc Main SLPM from Transfer Std		
Main/Auxiliary Flowrate (LPM) Setpoint	/	/
Average Temp (degC) / Press (atm) Setting	/	/
Main/Auxiliary Flow Adjustment Setting	/	/
Zero Fliter Reading (ug/m^3)		
Leak Test Flowrate Display Main/Auxiliary (LPM)	/	/
Analog Calibration. Date Last Performed		
MFC Hardware Calibration. Date Last Performed		
Mass Transducer Verification. Date Last Performed.		

COMMENTS

Calibrated By_____ Checked By_____
MLD-131 (01/95)

Figure Z.2.0.4
TEOM Calibration Report